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Keeping Basements Dry

From the Editor . . .

Comments on the latest proposed code changes have been reviewed by many code users over the past four months. One of the major challenges facing code officials will be the proposed objective-based code structure. Theoretically, an objective-based code gives designers and builders the freedom to investigate and implement new ways of building.

However, recent City of Vancouver decisions give me some concern about how objective-based codes will be interpreted. Vancouver has not accepted a number of different construction details that are technically sound, have been used for some time throughout North America, and with which even some local field inspectors are comfortable.

Presently, the building code for Part 9 construction, which applies to houses and low-rise residential construction, is basically a prescriptive code. It tells builders and designers in great detail how a building is to be built. It was drafted in this way because the assumption was made that the buildings would be simple and built with minimal specialized professional assistance. By and large, just following the code would result in a durable, structurally sound and safe building.

When changes to standard construction practices are proposed, or the use of innovative technologies not explicitly spelled out in the code is desired, the code still allows for their use, but by way of an "equivalency" to the prescriptive requirements. Some equivalencies using new products or technologies such as an insulation material that is not yet covered by standards identified in the code become routine until the code is updated. Local building officials accept their use by requiring that a registered professional, typically an architect or engineer, sign off on their application.

Other equivalencies of a design or of innovative technical detail may require a more formal presentation by the proponent with the reasons why the suggested detail should be accepted. This typically requires additional documentation that includes a reasoned explanation why the proposed detail will work, and perhaps test and research results. Again, a professional has to assume responsibility for the work. In this case, the building official has to be comfortable that enough backup information has been presented and is reasonable in terms of its substance.

Recent decisions in Vancouver cast doubt on how open the city is to equivalencies. Equivalencies are hard to obtain unless sanctioned by a third party agency such as CCMC, regardless of a submission's technical merits. It seems that liability paranoia prevails at Vancouver City Hall, despite a unique provision in the city charter stating that Vancouver cannot be held liable for the actions of its officials. The chief building official has noted that he has lawyers looking over his shoulder at his every action and, as a result, will not take action unless it is sanctioned by another organization.

What is disturbing about the Vancouver situation is that this is a jurisdiction with a depth of technical expertise in its building department that should be able to do a technical review of submissions presented to it. An overly cautious, hesitant approach could be understandable in a small jurisdiction limited technical expertise, but not in a major city with a large staff of professionals. My concern is how, in today's legal environment, other jurisdictions will deal with an objective-based code once it is implemented.

Richard Kadulski,
Editor

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Foundations:

Keeping Basements Warm, Dry and Healthy

A foundation provides solid bearing for the structure above it. Canadian houses are built with full depth basements largely because a deep excavation has to be dug to put the footing below the frost line, which in cold regions can be 4 or 5 feet deep.

Soil is full of nasty things we don't want inside our homes. These include soil gases such as radon, methane and other contaminants that may be natural or man-made, and moisture. Moisture is the main cause of problems. The quantities of moisture that can enter a house through the foundation vary seasonally, and depend on the depth of the water table, precipitation in the locale, soil type, and construction details. Proper construction details can avoid most of the problems.

Until recently, basements were not considered to be suitable living spaces. The excavation was done to build support for the structure, and the basement was used as a convenient space to store fuel for the heater (wood or coal) and as a cold storage cellar. The basement space was acknowledged to be an unhealthy environment for people.

Today basements are built with the expectation that they will be used as a fully developed, conditioned space even if that may not be the case at the time the house is finished. However, we have not changed the way we build basements to match the expectations for the way the space will be used. Basement issues remain at the top of the list for warranty complaints. To build durable, healthy basement spaces we need to review how we build foundations.

It is not commonly recognized that high moisture levels in the home can be the result of ground moisture entering through the foundation. Older houses are especially vulnerable, since less attention was given to ground water in the past and foundation walls were generally poorly built.

The simplest way to avoid basement problems is not to build basements, especially in high water table areas, in areas with wet soils or where soil gases are known to be a problem. Unfortunately, most people expect basement space. In some jurisdictions building and development regulations push builders to develop basements if they want to maximize allowable square footage.

Managing Moisture

Good foundation design and construction must deal with ground moisture. What we forget, or do not understand, is that concrete is not waterproof. Standard concrete acts like a rigid sponge. Ground moisture can be wicked a long way, pulled by capillary forces which can be very strong.

A concrete footing sitting in water will be like a thin drinking straw in a glass. Capillary suction forces can draw the water upward for long distances. That is why a good foundation design requires a capillary break be designed between the foundation and the soil. The bed of crushed rock under a slab-on-grade is there to provide a capillary break.

Standard construction details for treated wood foundations require the structure to be placed on a bed of crushed rock that extends past the foundation wall. The rock fill provides an effective capillary break that can also deal with storm water surges.

Technically, there is no reason why the same detail cannot be used for concrete footings (Fig. 1). Although standard practice is for footings to be placed on undisturbed soil, the building code does allow the footing to be placed on compacted fill. Some buildings are built that way, but it may require a structural or geotechnical engineer's review to review to ensure there is adequate carrying capacity for the loads imposed by the structure and occupants. This may be a small price to pay to reduce moisture problems.

Some may have concerns about the loads such fill can carry. The BC Advanced House was built in 1993 on top of a bed of crushed rock

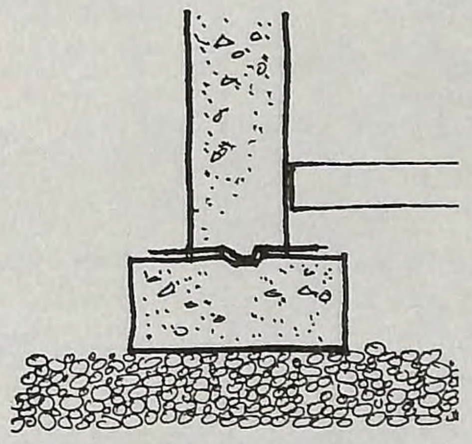


Fig. 1. The footing can be placed on top of a drain rock bed to create a capillary break. An alternative, if the footing is poured separately from the foundation wall, is to place an impermeable membrane between the footing and wall to stop moisture movement up the wall.

Fig. 2. Whistler Envirohome under construction. The ICF house is placed on top of structural rock/glass fill that also provides a capillary break for ground moisture.

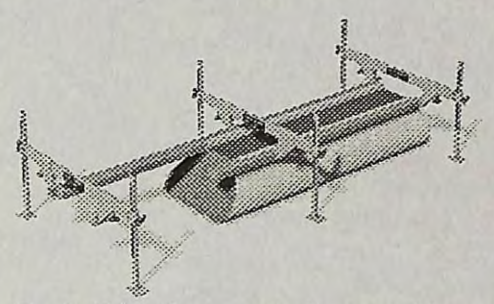


Fig. 3. Fabric forms made of impermeable fabric provide moisture resistance for footings.

and glass under the whole house which also managed the storm water. There has been no evidence of any structural problem.

An Envirohome currently under construction in Whistler, BC is a large three-storey structure (Fig. 2). The house is an all-concrete house using insulated concrete forms (ICF), with 35-foot high exterior walls. Even though the house is on a hillside, it has been placed on structural fill – a bed made up of a mix of crushed rock with recycled post-consumer glass.

There are several other ways to incorporate a capillary break. One is to put the foundation wall or footing on a water-impermeable membrane such as 6-mil poly. Another is to use fabric forms using an impermeable fabric that will not be stripped (Fig 3).

Perimeter Drains

Perimeter drainage is important in managing the ground water and removing it before it can build up any hydrostatic pressure against the foundation wall. The perimeter drain at the footing should never be expected to collect and remove rain water from the roof down spouts. That was standard practice until recently, but we know better today. In the Vancouver area, most jurisdictions require that roof down spouts be collected into a solid pipe, separate from the footing drain, which then only deals with ground water.

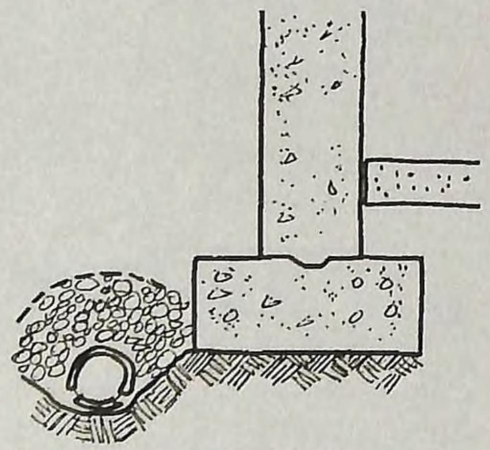


Fig 4. Perimeter drains placed in a trench below the footing lower the water levels at the footing, providing an effective way to keep water away from the footing.

The location of the perimeter drains also needs to be given attention. Perimeter drains always need to be at the lowest point possible, and below the level of the basement floor. If the footing is not placed on a crushed rock pad, the soil should be trenched so that the pipe will be lower than the footing. Such a trench must be done carefully so as not to undermine the bearing capacity of the soil. (Fig 4)

The drain rock cover around the pipe should also be wrapped with a filter cloth – not just at the top, but also below the pipe. The filter cloth will keep silt out of the drains.

Concrete Slabs

Concrete floors should be insulated, especially for rooms that will be used as living spaces. The most economic way in new construction is to lay rigid foam board (expanded bead board or extruded polystyrene) before placing concrete. The concrete slab can then be poured directly on top of the insulation or polyethylene sheet.

At one time suggestions were made that poly and insulation should be protected by a layer of sand. This is not a good idea because the layer of sand, with its fine spaces between the grains, becomes a water reservoir to supply water upward through the concrete slab. Excess water in the concrete cannot dry downward into the ground by vapour diffusion or by capillary forces because of the polyethylene sheet.

Basement Walls

Keeping basement walls dry and minimizing moisture penetration also requires rethinking how foundations are finished. Many people think that the black damp-proof coating on the foundation offers waterproofing protection. However, the name itself should tell us something. The damp-proof coating is simply an emulsion that seals microscopic pores in the foundation concrete to reduce capillary forces. It does not water proof.

The most effective waterproofing is offered by loose, porous materials that create a capillary break between the soil and foundation wall, and offer an easy drain path for any ground water to drain away. A number of these types of products are commercially available. If you use one of these materials, there is less need to be concerned about the installation of porous granular backfill against the wall. When these products started being used, it was discovered that they also reduced problems associated with frost action.

A product pioneered years ago was rigid fibreboard insulation applied on the exterior of the foundation. The surface layer of fibres creates a drain cavity. This is the principle behind proprietary foundation systems such as ***Drainclad*** by Owens-Corning or ***Drainboard*** by Roxul.

Today there are a number of dimpled membranes such as ***Delta MS***, ***System Platon***, ***MiraDrain 2000***, ***Hydro-Guard 2000*** and others. The dimples create an air space between the concrete and ground water, allowing the water to drain away. Because the membrane does not have to adhere to the surface and bridge small holes or cracks, the wall does not have to be parged, cleaned or sealed before hanging the membrane. These products are all variations of a foundation wrap membrane that functions even when torn.

Some insulation manufacturers produce insulation boards with grooves, such as Plastifab's ***GeoDrain Foundation Insulation*** or Dow's ***Styrofoam Perimate*** that are designed to provide drainage channels to direct water away from the foundation wall.

Some manufacturers have assembled packages of materials that are promoted as a system with some redundancies. One such example is Koch Waterproofing Solutions' ***TUFF-N-DRI® Basement Waterproofing System.***

Xypex Chemical Corp. has a cementitious coating that penetrates into the structure of concrete walls and floors, creating a non-soluble crystalline formation that becomes a permanent part of the structure and seals the concrete. It can be applied to wet concrete because the mixture does not depend on adhesion to concrete surfaces but is absorbed into pores and capillaries, plugging them and preventing water seepage. Coatings such as Xypex should not be relied on as a primary water protection, but can be effective for retrofits where there may be fewer options.

Basement Wall Insulation

The big issue is how to finish a basement wall; whether or not a vapour barrier is needed and, if so, where it should be placed. It is important to remember that there are two main sources of moisture that will affect performance of the construction. One is construction moisture – the moisture contained in newly placed concrete and framing materials. This is the moisture that it is important to manage the first one or two years as the assemblies cure and dry out. The second is environmental moisture. This is ground water, snowmelt, and rainwater, as well as moisture generated by the occupants. Usually, the occupant-generated moisture is a small quantity compared to the environmental loads.

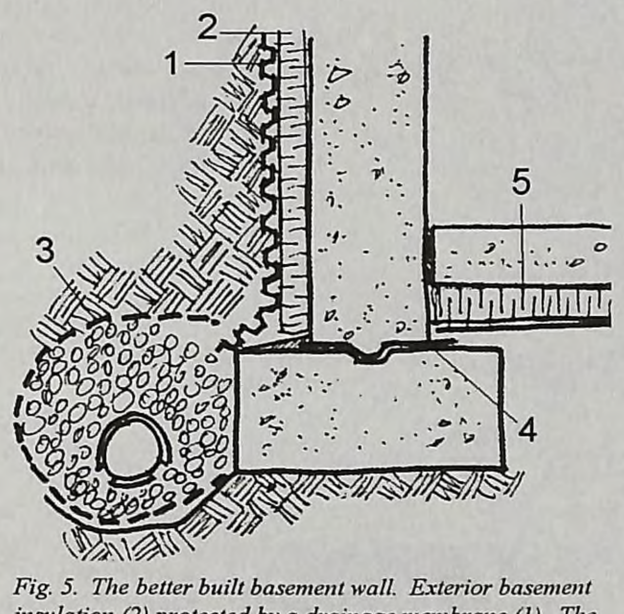


Fig. 5. The better built basement wall. Exterior basement insulation (2) protected by a drainage membrane (1). The perimeter drain tile is below the footing, and the drain rock is wrapped (3) with a filter cloth to reduce sedimentation. An impermeable membrane (4) reduces moisture migration into the foundation wall. The basement slab is placed on rigid insulation over a polyethylene membrane (5).

A basement wall will remain dry if it is built to handle the different ways in which water can move into and through basement walls. Walls will get wet at some point in spite of good design and construction, so the wall must also be able to dry. Drying typically means towards the interior. Foundation assemblies are rarely able to dry towards the exterior.

If the basement wall is insulated on the exterior, which is the preferable option, there should be no need for an interior moisture barrier. The interior finish still needs to be finished to provide a continuous air barrier, and the interior paints should provide adequate vapour diffusion resistance. The small amount of vapour permeability of the paints will allow any minor amounts of moisture to dry into the interior, while polyethylene, which is a near-perfect vapour barrier, restricts such drying.

Moisture movement by diffusion can travel inward or outward, depending on the conditions and time of year; that is why some controlled permeability is acceptable. The source of moisture can be a result of air leakage, or capillary water movement. Air leakage is reasonably well understood, and can be managed relatively easily. Capillary moisture

The building code defines a vapour barrier as a material that has a vapour permeance no greater than 45 ng/Pa-m²s.

Vapour permeance of:

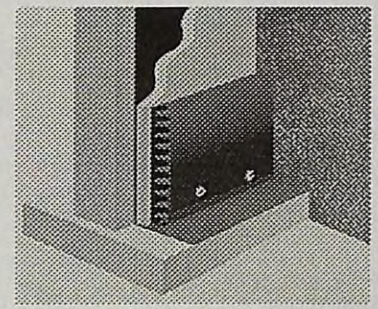
6-mil polyethylene is	3.4 ng/Pa-m²s;
0.01 mm aluminium foil	2.4 ng/Pa-m²s;
1 coat vapour retarder paint	26 ng/Pa-m²s

movement is subtler, less well understood, and consequently a major source of moisture problems.

If there is no insulation on the exterior of the basement wall, then a careful analysis needs to be made of the conditions where the house is located. The temperature gradients, the moisture sources, and the location of capillary breaks must be considered in order to determine how much insulation is placed where and, what is more important, the nature of the moisture and the vapour barriers that may be needed. ☼

TUFF-N-DRI® Basement Waterproofing System by Koch Waterproofing Solutions, Inc. This is a three-component proprietary system that deals with leakage, seepage and interior condensation in new basements.

The first component is a polymer-enhanced asphalt membrane that is spray-applied on the exterior of the foundation wall to provide a consistent and seamless membrane. It has a dry thickness of at least 40 mils and is intended to span foundation-settlement cracks.



The second component is WARM-N-DRI® foundation board. This is an insulation board that is applied over the waterproofing membrane. It eliminates the need for an interior moisture barrier because the indoor-outdoor temperature difference on the basement's interior wall is reduced, thus decreasing the conditions that promote interior condensation.

The third component is DrainStar® strip drain, which is placed on the outside of the insulation to assist with moisture drainage. It is a rigid polymer sheet with cones that collect and move water away. The cones are covered by a non-woven geotextile filter fabric that strains out backfill soils and other particles.

Information:
Koch Waterproofing Solutions Inc. Tel. (800) DRY-BSMT
http://www.kochwaterproofing.com

Performance of Dual-Flush Toilets

The 6-litre toilet has now been mandated throughout the United States and is considered standard technology in most parts of Europe. At this time Ontario is the only Canadian province with such a requirement. The Ontario Building Code requires the installation of 6-litre toilets in new construction compared to earlier "water saver" 13- litre toilets and even older 20+ litre toilets.

Many municipalities across Canada, especially those facing water supply problems, have subsidized toilet replacement programs in an attempt to increase the market penetration of water-efficient toilets and reduce overall water consumption.

The dual-flush toilet takes water conservation one step further than the 6-litres-per-flush toilet. It was developed in the early 1980s and has a two-step flush option. It uses 6 litres of water to flush solid waste but only 3 litres to flush liquid waste. This technology has now been mandated in Australia and Singapore but is still relatively new in North America.

A CMHC project looked at the performance and user acceptance of dual-flush toilets. A total of 70 toilets were installed as retrofits in both residential and commercial applications in various locations across Canada. Before installing a dual-flush toilet, the water consumption of the existing toilet was measured. Dual-flush toilets performed well compared to 6-litre and 13-litre toilets and saved an average of 26% more water than single-flush 6-litre toilets when used in a replacement program.

Significant water savings were achieved by replacing existing toilets with dual-flush toilets. Flush volumes were reduced 68% in single-family

dwellings, and 56% in office washrooms.

The study found that a range of flush volumes existed for all toilets used in the program. Most of the existing toilets replaced were older 13- and 20-litre units with a measured flush volume ranging from 6.2 to 29.4 litres.

Even the dual-flush toilets can have a range of water consumption volumes. The Caroma dual-flush toilet long flush volume ranged from 5.0 to 7.2 litres and the short flush ranged from 2.5 to 4.3 litres. The TOTO 6-litre flush volumes ranged from 5.4 to 6.6 litres, while the Niagara 6-litre flush volumes ranged from 5.6 to 6.7 litres.

The study showed a small increase in the average number of flushes per day at sites where dual-flush toilets were installed. However, there is not enough information to determine if the increase in flush rates at dual-flush sites is related to flush performance (i.e. the need for double flushing), or simply because of people's curiosity about how the toilets work.

Users were surveyed for their opinion on the units. In terms of appearance and the ability to clear solids and liquids, more than 85% of the dual-flush surveys were rated either "good" or "satisfactory," and 66% of the respondents said they would definitely recommend dual-flush toilets to others. Despite some complaints about bowl streaking, all survey respondents indicated they liked the dual-flush option. ☼

***Dual Flush Toilet Project** by Veritec Consulting Inc. for CMHC Research Division.*

Noise from Plumbing Pipes

When indoor plumbing was first developed, pipes were made of heavy cast iron, the number of fixtures in a home was limited, and noise was not as big an issue as it is today. In recent years, the number of fixtures in a house or apartment has increased significantly, and most plumbing is now done using light-weight plastic materials. Complaints about plumbing noise have also increased.

Noises from plumbing pipes are a major irritant in a home. No one wants to be sitting in the living room entertaining visitors and hear the gurgling of a toilet flush going through a pipe in the wall.

Is there a way to suppress plumbing pipe noises? Is a cast-iron drainpipe quieter than plastic plumbing?

A study for the Cast Iron Soil Pipe Association and CMHC was done to measure the noise produced by 3-inch diameter drain, waste, and vent pipes made of cast iron, PVC and ABS. The study measured the type of noise emitted by the drainpipes during a 6 litre (1.6 gallon) toilet flush in a typical single-family dwelling or multi-unit building. All pipes were installed identically and tested under the same conditions.

The experimental setup for the study was typical of drain pipe installations found in most homes. A toilet was discharged into a 3-inch horizontal waste pipe connected to a 3-inch vertical waste stack in a wall with 0.5 inch gypsum board on both sides.

An increase or decrease of 3 decibels (dB) or less is barely noticeable. An increase of 10 dB to the human ear leaves the impression that the sound has doubled, while a decrease of 10 decibels gives the impression that the sound has been reduced by half.

The test found that there was little variation in the noise levels between the different PVC pipes and little variation in vertical cast iron pipes, but a reduction of up to 7 dBA was noted for horizontal cast iron pipes in unenclosed spaces.

Tests on partially enclosed assemblies highlighted a significant difference in the noise pattern of horizontal drain and vertical stacks. For cast-iron pipe assemblies, vertical pipes produced more noise than horizontal ones.

The opposite was true for PVC and ABS pipes: Horizontal pipes produced more noise than vertical ones.

A drywall enclosure also provides a lot of the noise reduction. The amount of sound reduction does not seem to be dependent on the type of pipe.

Overall, drainpipes made of cast iron were found to be quieter than PVC and ABS pipes. There can be a difference of 6 to 10 dBA between cast iron and PVC and as much 15dBA between cast iron and ABS. ☼

Noise Produced by DWV Pipes Made of Cast Iron, PVC and ABS
CMHC Research Division

A Life Cycle Environmental Impact
Comparison of 1970s & R2000 House Designs

by Jamie Meil, Vice President, Athena Sustainable Materials Institute

What is the environmental impact of a typical Canadian house? What are the changes in houses built in the 1970s and those today?

Any type of construction embodies significant environmental impacts. R2000 homes, however, have a much better operating energy performance over their life. To gain this improvement requires the use of more materials with a higher embodied effect, but the increased effects of R2000 homes are modest and more than offset by the significant reductions in energy used for space heating and air conditioning over the building's life.

The Athena Sustainable Materials Institute compared the environmental performance including embodied environmental effects for single-family home designs as typically built in Canada from the 1970s through to the present. The work was part of long-term NRCan research to improve the sustainability of Canadian housing by a factor of "4" initially, and ultimately by a factor of "10".

The study was based on the "as built" design of the Canadian Centre for Housing Technology houses located on the National Research Council's property in Ottawa. Specifications for the same house as it would have been built in the 1970s were compared with today's R-2000 compliant construction. Table A outlines the major material and design differences between the two house designs.

The environmental assessment considered the effects of initial (embodied) energy use, raw material use, transportation, and construction for the structure, partitions and envelope components, as well as the impacts of maintenance and replacement over an assumed 30 year life span.

Site preparation and landscaping; interior finishes beyond initial gypsum board installation; and furnishings were not considered. The "end-of-life" disposition was not considered either because of the difficulty to adequately forecast the homes' actual life spans.

The results provide a conservative estimate of the total life cycle environmental impacts of building and maintaining a home over its life. They offer a valuable benchmark for assessing various options for reducing the embodied environmental effects of future housing designs.

The study used the Environmental Impact Estimator, a software tool developed by the Athena Institute. The Environmental Impact Estimator is the only North American software for the life cycle assessment of buildings and can model 95% of the building stock on the continent. Architects, engineers and researchers can use it to assess the environmental implications of industrial, institutional, office, multi-unit residential and single-family residential building designs. The software covers a building's life cycle stages from the "cradle" (natural resource extraction) through to its "grave" (end-of-life), including on-site construction and maintenance.

The software and underlying databases represent average or typical manufacturing technologies and conditions for six Canadian regions — Vancouver, Calgary, Winnipeg, Toronto, Montreal and Halifax — as well as two US regions and a US average.

Material and Design Summary

For both designs, a 30-year life span was used, which is the length of a typical mortgage. Although arbitrary, the 30-year life provides an initial and conservative reference basis for the study. In practice most houses are used for a much longer time period.

The study assumed that the roofing would be renewed every 20 years, so in year 20, a second layer of shingles would be added to the initial layer. At year 30, the roofing added at year 20 would still have another 10 years of life, so to confine the analysis to 30 years, only half of the materials and their consequent embodied environmental effects for re-roofing were attributed to each design.

Embodied Effects: The full range of environmental effects associated with the manufacturing, transportation, use and disposal of building products or components.

Operating Energy: The energy used to heat and cool the space and meet lighting and plug load needs.

Note: Operating energy itself has embodied effects associated with the production and transportation of the energy.

1970s design

It was assumed that the ceiling insulation would be upgraded from 6" (R20) to 8.5" (R28) in year 20 (1990-standard), and that the original wood windows would be replaced at the end of 20 years with PVC windows having both a low "E" coating and argon fill between the two panes. By year 30, it was assumed that 12% of the new thermal glazing units would have failed and been replaced (obviously, these failures would not have occurred all at once, but over the 10-year period — for modeling purposes, the team selected to model the failures at year 30).

R2000 design

It was assumed that at year 20, 25% of the window units would have failed and been replaced, and that over the next 10 years (to year 30), 50% of the window units would be replaced. Clay brick should last the life of the building and may require repointing, but repointing was ignored because it is likely to be of minor significance.

Results

It was discovered that each square metre (10 sq. ft) of the 1970s house, built and maintained for 30 years

- embodied 2.4 GJ of energy and required 0.6 tonnes of raw materials;
- produced greenhouse gases the equivalent of 350 kg of CO_2;
- required 44 cubic metres of air and 15 cubic metres of water to dilute these pollutants to acceptable levels; and
- resulted in 30 kg of solid waste.

From an embodied energy perspective, the structure and envelope each account for roughly 50% of the building's initial environmental burden. Together, they account for more than 90% of the total embodied life cycle burden, the balance being maintenance and replacement. For the initial structure, the below grade component is the single largest contributor to the environmental load for the structure. Concrete and steel (used in the beams, lintels and columns supporting the wood floor) are the main reason for the below grade component's big environmental cost. This is equally true for the R2000 design.

Table A

Building Component	1970s construction	R-2000 Design
Floor area	207.4 m²	207.4 m²
Design Life	30 years	30 years
Primary structure	wood frame construction, concrete basement	wood frame construction, concrete basement
Envelope	2x4 studs (GRN), R-12 fibreglass batt insulation	2x6 studs (KD), R-20 fibreglass batt insulation
Windows	Wood windows, standard double glazed	PVC windows, low-E, double glazing, argon fill
Exterior cladding	Brick	Brick
Roofing system	Wood frame truss, asphalt shingle, R-20 fibreglass batt insulation	Wood frame truss, asphalt shingle, R-50 fibreglass batt insulation

By far the largest contributing component to the overall energy and environmental impact of the above grade envelope (as distinct from the structure) is the clay brick, which was used on the exterior, followed by gypsum board and insulation materials.

While comparing the impact of the structure, envelope materials, maintenance and replacement components is useful, the quantity of the total energy involved can easily go unnoticed. A quick calculation showed that the life cycle energy embodied in the 1970s home design is equivalent to the energy needed to drive a small car (consuming 8L/100km) a total of 191,000 km, or eight times around the earth.

R2000 Design

Compared to the 1970s design, the R2000 design embodies about 20% more energy. The structure and envelope are both more energy intensive because more materials are used in the exterior wall (2"x 6" studs instead of 2"x 4"), kiln-dried studs are used (rather than green, unseasoned lumber in the 1970s design) and more insulation is added to both the walls and roof. The maintenance and replacement impacts are lower because the roof insulation does not need to be upgraded nor will all the window units be replaced over the 30-year time line.

R-2000

For information on the R-2000 Program, contact your local program office, or call 1-800-387-2000 www.R-2000.ca

For more information,
Athena Sustainable Materials Institute
www.athenaSMI.ca
CANMET Energy Technology Centre, NRCan,
www.nrcan.gc.ca/es/etb.

Operating Energy

Annual space heating costs for the R2000 home are only 27% of the costs of heating the 1970s home (a factor of 4 decrease). Total R2000 annual operating costs are 42% of 1970s costs, and the total 30-year life cycle energy of the R2000 house is 46% of the 1970s figure. About half of the total improvement in operating efficiency can be accounted for by better envelope design, with the remainder a function of higher mechanical equipment efficiency.

Total Embodied and Annual Operating Energy Comparison Summary

Compared with the 1970s design, the R2000 design embodies 20% more energy, emits 25% more air pollutants and 25% more global warming gases. However, when these embodied effects are combined with those of space heating, the R2000 house ends up using 60% less energy and emitting 61% fewer greenhouse gases over a 30-year time period. ☼

Technical Research Committee News

Canadian Home Builders' Association

Competition Bureau Settles Case Involving Radiant Paint

The Competition Bureau has settled a case regarding the marketing practices of Para Inc. of Brampton, Ontario. The consent agreement concerns the ***Radiance***™ line of low e-line paint, a product that has been sold in Canada since 2001. The manufacturer claimed the paint would generate energy savings for its users.

As a result of an analysis of tests on Radiance paints, the Bureau and Para Inc. have agreed to limitations on performance claims made in the marketing of this paint. The manufacturer has agreed:

(a) not to claim energy savings greater than 5 per cent in an average residence;

(b) to state that the energy savings will vary according to the climate where the building is located and the quality of the building's construction, among other factors;

(c) not to state the heat transference qualities without identifying the energy saving qualities in accordance with (a) above.

The agreement reached ensures that the parameters regarding potential energy savings are set out before any future advertising of average energy savings is provided for the product.

The Competition Bureau is an independent law enforcement agency that ensures all Canadians enjoy the benefits of a competitive economy.

Fire Stopping of Service Penetrations in Buildings: a Best Practice Guide

The Technical Research Committee (TRC) is the industry's forum for the exchange of information on research and development in the housing sector.
Canadian Home Builders' Association, Suite 500, 150 Laurier Ave. West, Ottawa, Ont. K1P 5J4
Tel: (613) 230-3060
Fax: (613) 232-8214
e-mail: chba@chba.ca
www.chba.ca

Fire stopping of construction, especially for multifamily dwellings, is important. How to properly detail and install fire stopping is challenging, and many in the industry unfortunately do not fully understand the requirements or the intent behind them.

The City of Calgary has prepared a guide that assists designers, builders, suppliers and code officials to understand the requirements for fire stopping penetrations through fire separations in buildings. The 98-page document primarily addresses issues in multifamily residential construction, but its concepts can apply to any type of building, other than single-family and two-family dwellings and townhouses where no services pass through from one unit to another.

Creation of the paper was triggered by industry changes in recent years, brought on in part by:

- Changes in codes that allow larger multifamily buildings to be built with wood framing.
- Advances in fire stopping systems.
- The increased number of larger wood-frame, multifamily projects being constructed.
- Single-family homebuilders moving into multifamily homes without the full knowledge of the differences between single and multifamily construction.

Designers, builders, developers and building officials have had to struggle with the increased complexity and variety of materials and construction systems. The challenges have been the greatest in multifamily, wood-frame apartment buildings, which have a large number of fire separations.

The City of Calgary guide is intended to help all involved gain a better understanding of the requirements, of the options available, and make informed choices about how to select appropriate systems for buildings. It was created by a committee of builders, designers, contractors and building officials and outlines examples of typical solutions proposed by this industry group. It is a very readable, fully illustrated document, with direct references to the code. Short, relevant bits labelled "Hot Tips" with additional explanatory material are found throughout.

Fire Stopping Service Penetrations in Buildings
Building Regulations Division
City of Calgary, Planning Information Centre
Telephone: (403) 268-5333
Fax: (403) 268-1319

The guide is a large file, but is available for download in PDF format from the City of Calgary Web site at: http://www.calgary.ca/DocGallery/BU/planning/pdf/1151_fire_stopping_manual_2003.pdf

HOT TIP

Abandoned Openings

Sometimes a hole is cut in error and no pipe, wire or mechanical equipment is installed through the opening. When this occurs, close the opening using the same type of fire-resistive construction used to construct the original fire separation. Alternatively, a fire stop system tested for this purpose could be used to seal the opening.

HOT TIP

A Bit of History

On November 21, 1980, the MGM Grand Hotel in Las Vegas experienced a fire on the first floor of the hotel. Smoke and gases from the fire found their way to higher floors through seismic gaps, plumbing and electrical openings. A total of 67 victims were found on the 16th or higher floors. The fire never spread beyond the main floor.

HOT TIP

What Does "Tightly Fitted" Mean?

Consultation with code writers at the national level has revealed that they interpret "tightly fitted" to mean cast-in-place or grouted-in-place (for metal pipes only). If this type of fire stopping is not used, then a fire stop system is required. Normally cast-in-place or grouted in place would only apply to where a concrete floor or wall is being penetrated. Provision for expansion and contraction of the building service needs to be accommodated, so that the seal around the service is not broken by movement when the fire stop is cast or grouted in place.

Builders Without Borders

Builders Without Borders is a Canadian non-profit organization created by building industry volunteers experienced in the planning, design, construction, and maintenance of shelter. Its members include architects, engineers, planners, project managers, building trades, construction specialists, procurement individuals, and instructors in shelter-related disciplines.

The objective of Builders Without Borders is to provide opportunities to building industry volunteers and consultants to build shelter, teach building industry skills to those most in need, and to do this without prejudice regarding race, religion, gender or political affiliations. They believe that the most effective way to provide development assistance for those most in need is to work with Canadian and international non-government humanitarian organizations and supply them with experienced construction industry volunteers. They have established a worldwide network of building industry and professional groups in many countries, and are able to draw on local construction industry knowledge to quickly determine costs and available resources when called on.

Builders Without Borders recruits volunteers from across Canada. They also receive requests for financial assistance, construction materials, equipment, and hand tools. For information, or if you can make financial, material or equipment donations contact:

Builders Without Borders Foundation
Tel.: (604) 738-7516
Fax: (604) 738-7518
E-mail: neilgriggs.bwb@telus.net
www.landcentre.ca/builders/index.htm

Building Solar-Ready Houses

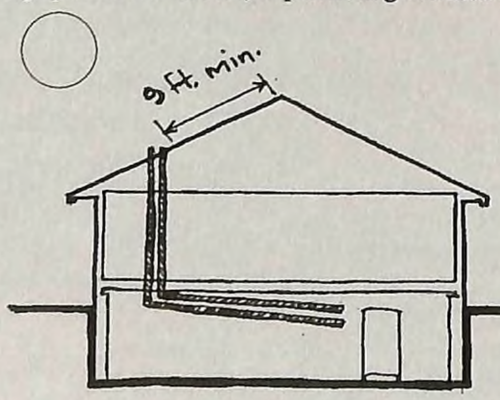
Solar energy can provide a major portion of the energy needed to maintain comfort conditions in the home.

Passive solar design features can contribute a significant portion of a house's space heating needs. Active solar systems can provide 40 to 60% of annual domestic hot water needs.

Solar water heating is a practical and economical way to save on water heating costs and to reduce greenhouse gas emissions. Adding a solar water heating system as a retrofit is easy if the building is solar-ready. Taylor Munro Energy Systems, a Vancouver solar systems manufacturer and solar equipment distributor, is promoting the idea that builders incorporate a "solar-ready" package in their homes, which could also be used as a low-cost marketing feature.

Making a house "solar-ready" means pre-plumbing the house for a future solar water heater system. The roof must, of course, have reasonable south exposure (but it could also be any orientation between southeast and southwest). What you need to do is install a feed and return water line and a sensor wire from the mechanical room to a south-facing roof.

✔For homes with up to four occupants, use ½" insulated copper pipe. For larger homes, use ¾" insulated copper pipe.
✔For controls, use 1-pair shielded sensor wire, 18-gauge minimum.
✔Slope all plumbing towards the indoor heated space so the system can drain back into it. This provides automatic freeze protection and allows the system to operate year-round.
✔Penetrate the roof as low as possible (at least 9 ft down from the ridge) on the south side, leaving room for the solar collector array.
✔Cap the roof penetration in accordance with local standards. ☼



Information:
Taylor Munro Energy Systems
info@taylormunro.com

Vapour Diffusion Ports: Do They Help Walls Dry?

Effective moisture management for walls requires thinking about the 4 D's of moisture management: deflection, drainage, drying and durability. Until recently, most building systems had enough redundancies and were robust enough that drying received little attention. The Building Envelope Research Consortium (BERC), an industry and government group formed to deal with building envelope failure problems in B.C. undertook a number of research activities. One was the Envelope Drying Rate Analysis experiment that looked at the drying rates of various assemblies under laboratory conditions.

The impact of low permeance panel sheathing products like plywood and OSB has been a major concern. Typically, permeance is used in calculating drying rates. However, the actual effective permeance of a wall may be greater than the calculated permeance.

One construction detail that has been used for years to enhance the drying potential has been to put saw cuts into each stud bay or to leave a gap between panels.

An updated approach to saw cuts has been initiated by Vancouver architect Brian Palmquist of ECO-design.ca Architecture + Building Ecology Ltd. and involves cutting one or two 3-inch diameter holes in the sheathing at the top and bottom of each stud space. These holes have been called vapour diffusion ports (VDPs) and are meant to allow moisture in the stud space to contact the sheathing membrane directly and dry out.

Do these holes really work? Do they help walls dry?

Forintek Canada evaluated the effect of the vapour diffusion ports on the drying potential of wall test panels in a controlled laboratory environment that simulated the winter climate of Vancouver. However, the test conditions did not mirror real life weather exposure with its random wetting and wind effects that can help speed drying of vented rain screen cavities. Nor were there any penetrations such as windows or vents.

The test measured how long it would take the sample wall panels to dry with and without the ports when they had been wetted to a moisture content (MC) of more than 25%. (The code requires framing lumber have no more than 19% MC).

The 4 ft. by 8 ft., 2 x 4 stud test panels were fully clad with stucco on either 11.5 mm (15/32 in) oriented strand board (OSB) sheathing or 12.5 mm (1/2 in) softwood plywood sheathing. VDPs were cut in each of five panels; two at the top and the two at the bottom of each stud space. For comparison, one panel was tested without VDPs. All panels had rain screen cavities either 19 mm or 10 mm wide.

What was found?

No test panels completely dried to less than 19% MC by the end of the test, but some components did have a reduced moisture content. On average the framing dried to less than 19 % MC in less than 27 days. The stud moisture content at the start was 34% and at the end of the test averaged 12%. However the OSB and plywood sheathing generally stayed at 19% MC or higher to beyond the end of the test.

Panels with VDPs dried faster than those without. A drying trend was noticed as early as 25 days into the test, while panels without VDPs did not enter into the final drying stage until after 34 days into the test. OSB sheathing without VDPs finished with an average moisture content in the range of 35 to 36%, but with VDPs they were in the range of 22 to 25%. This improvement in the drying of OSB panels was also achieved in a shorter drying time. While the performance of the panels with OSB sheathing improved with VDPs, there was no difference in the drying rate of the plywood panel with VDPs.

It seems that in the first 20 days there is a redistribution of moisture in an outward direction, from the framing to the sheathing. Once the redistribution is done, over the next 40 days there is very slow drying in the panel overall.

Another observation was that panels with top and bottom vented rain screen cavities dried faster than if they were vented only at the bottom. In other words, the air movement enhanced the drying.

Vapour diffusion ports can make a difference in OSB-sheathed walls, but not in plywood sheathed walls. ☼

Evaluation of Vapour Diffusion Ports on Drying of Wood-Frame Walls Under Controlled Conditions
Donald G. Hazleden of Houseworks Building Science and Paul I. Morris of Forintek Canada Corp. for CMHC Research Division

Carbon Monoxide Detectors: Do They Work?

There are many potential sources of carbon monoxide (CO) in a home. These include unvented cooking appliances, wood burning stoves or fireplaces, gas, oil or wood furnaces and water heaters, gas appliances, attached garages, tobacco smoke, and blocked chimneys. Carbon Monoxide is a deadly gas, whose health effects are related to the level of concentration and length of exposure. Some building codes, and the R-2000 Standard, now require the use of CO detectors if there is a combustion appliance or an attached garage in the house.

With the increased reliance on CO detectors, we need to know whether or not these detectors really work, especially as concerns have been raised about the effectiveness of the alarms. There have been many reports questioning their reliability, and in some areas CO alarms have gained a reputation for poor performance. Although several North American cities have already passed regulations requiring that CO alarms be installed in homes, poor experience with them has discouraged others from following suit.

One of the challenges is that the source of the CO may not always be readily apparent, especially if the source is in the garage, since there can be a delay in the gas movement into the house.

False alarms diminish homeowners' confidence in alarms. We know that alarm fatigue limits the effectiveness of smoke alarms. After a false alarm some consumers may intentionally disable their CO alarm; or worse, tired of an alarm that "cried wolf" too many times, they may ignore future alarms. Because of their high false alarm rate, and the inability of consumers to determine the legitimacy of an alarm, an even more pronounced effect may be happening with respect to CO alarms. A US study of consumer attitudes toward CO alarms found that most people place little trust in CO alarms; 62% responded to an alarm activation by ignoring it.

Most consumers assume that certification of an alarm to a UL standard will ensure that the detector will work properly. However, it appears that certification does not guarantee it will work. In California alone, more than one million nonfunctional CO alarms have been recalled from the market as a result of incidental testing by a gas company. The alarms had been certified by Underwriters Laboratories to the UL 2034 standard even though it turned out they were unable to alarm at deadly CO levels.

... certification does not guarantee an alarm will work.... alarms certified to the UL 2034 standard were unable to alarm at deadly CO levels... but alarms certified to the CSA 6.19-01 standard work.

The Gas Research Institute (GRI) in the United States recently released an in-depth report on the results of tests of CO alarms. More than 100 units of 14 models were purchased off-the-shelf from normal retailers. The tests were done according to both the UL Standard 2034-95 and the CSA Standard CSA 6.19-01.

The results showed there are consistent problems with existing CO alarms, especially those certified by UL. The poor performance of commercially available residential CO alarms was attributed in part to shortcomings of the UL 2034 standard itself. The UL standard does not incorporate the quality control and assurance measures that are standard in many other industries. It does not require that an appropriate sample be tested to ensure that alarms meet appropriate performance specifications and do not have inordinately great failure rates.

Among the significant failings observed were the following:

False Alarms – Four percent of the units had a false alarm in clean air. This study did not investigate detector behavior at high humidity, which is also associated with high false alarm rates, especially false alarms resulting from morning fog and rain.

Failure to Alarm – A significant number of the alarms failed to alarm at hazardous CO levels. 35% of alarms tested failed to alarm when presented with one or more of the CO concentrations set out in the UL 2034 sensitivity test, and 37% failed to alarm at low humidity.

Poor Sensitivity at Low Humidity – When tested at low humidity conditions (but twice the lowest humidity required by the UL 2034 standard) many alarms were not sensitive enough to CO. 37% failed to actuate. In general, those brands which failed to alarm at low humidity were also likely to fail at moderate humidity.

Inaccurate Digital Displays – Three of seven brands with digital displays were accurate to ±30% of the true concentration. One of the three was accurate to within ±10%. The other four were not accurate enough to meet the basic sensitivity specification of the UL Standard. A number of the alarms of two brands read zero ppm when exposed to CO concentrations as high as 100 ppm.

Poor Response to Varying CO Levels – Even when some alarms activate at the UL test concentrations they do not necessarily activate an alarm at other life-threatening CO concentrations. Of the fourteen brands tested, seven show decreased sensitivity to steadily increasing CO concentrations compared to fixed concentrations.

Unlike UL 2034, the recently developed Canadian CSA 6.19-01 Standard for Residential CO Alarms has incorporated requirements for quality assurance, and specifications for alarm longevity and time-of-manufacture testing. The US report confirms the benefits of the features in the CSA 6.19-01 standard performance criteria and recommends that US regulators require CO Alarms to be certified to the CSA standard.

The effective date in Canada for CSA 6.19-01 is January 1, 2003. An alarm meeting this standard can be recognized by the CSA Blue Flame/Blue Star logo and must indicate the standard the device is tested to. ☼

Evaluating the Performance of Residential CO Alarms *for The Gas Research Institute. The full report can be viewed and downloaded from www.gri.org*

Mechanical Contractors' Plea

Mechanical equipment installation is a challenge for builders and mechanical contractors. "That's all the room they gave us" is what one hears from mechanical contractors when asked why it is impossible to access a furnace or heat recovery ventilator for servicing or to change the filter.

Energy and cost efficient, quiet and maintainable mechanical systems must have enough space. As designers and builders, we give the owner a beautiful piece of eye candy. Owners also deserve the same from their heating and ventilation system. While awed by the magnificent architectural features, users also expect a comfortable environment. As we know, problems inevitably happen at the worst possible time. Servicing delays caused by difficulty accessing the system can become a big irritant.

Keep this in mind for future projects. ☼

Energy Answers

Rob Dumont

What are the sun angles above the horizon on December 21 (the winter solstice) at solar noon?

The sun angle is strongly dependent on the latitude. The further north you go, the lower the sun angle. Here is a formula you can use in the northern hemisphere to determine the sun angle at any latitude on solar noon on December 21.

sun angle above horizon = 90° - 23.5° - latitude angle

23.5° is the declination (tilt) of the earth's axis relative to the plane of the earth's rotation around the sun.

For Saskatoon, located at 52° N latitude, the sun angle at noon on December 21 is 90 - 23.5 - 52 = 14.5°. For Point Pelee, the southernmost location in Canada at 42°N, the sun angle is increased to 24.5°

Location	Latitude (°N)	Sun Angle at Solar Noon December 21
Windsor	42	24.5
Toronto	44	22.5
Halifax	45	21.5
Montreal	45	21.5
Ottawa	45	21.5
St. John's	48	18.5
Vancouver	49	17.5
Winnipeg	50	16.5
Calgary	51	15.5
Edmonton	53	13.5
Yellowknife	62	4.5
Iqaluit	64	2.5
Inuvik	68	1.5

Here are the sun angles in winter at solar noon on December 21 for various locations in Canada:

Note that Inuvik, located at 68° N, has a negative sun angle on December 21. (In other words, the sun is below the horizon.) Inuvik is north of the Arctic Circle, and all locations north of the Arctic Circle (66.5° N) will be in darkness on that day.

I once did some work for Natural Resources Canada in Aklavik in early December. Aklavik is at about the same latitude as Inuvik. I can remember that dawn, solar noon, and dusk all occurred at about the same time! The sun barely peeked above the horizon at that time of the year. In summer, however, on June 21, the sun is up 24 hours a day at that location.

Every place on earth has the same number of hours of daylight each year; roughly 12 hours times 365 days a year or 4380 hours. Your latitude determines how evenly those hours are distributed throughout the year.

I once worked on the equator in Kenya, and the daylight hours were 12 hours every day of the year. In Kenya they had a dinner drink called a "sundowner", and you could reliably have such a drink around 6 p.m. every day. Up in the high arctic you would have trouble trying to drink sundowners in the summer time, as there is no sundown! But I digress.

What are the sun angles at solar noon on June 21, the longest day of the year?

The sun angle at solar noon on June 21 at any latitude in the northern hemisphere can be determined from the following formula:

sun angle above the horizon at solar noon = 90° + 23.5° - latitude angle

Another way to calculate the angle is to add 47 degrees to the December 21 angles shown in the table above.

Location	Latitude (°N)	Sun Angle at Solar Noon on June 21
Windsor	42	71.5
Toronto	44	69.5
Halifax	45	68.5
Montreal	45	68.5
Ottawa	45	68.5
St. John's	48	65.5
Vancouver	49	64.5
Winnipeg	50	63.5
Calgary	51	62.5
Edmonton	53	60.5

Note that nowhere in Canada will the sun angle come close to 90 degrees at any time of the year, even in the most southern part of Ontario.

What is the best location and size for a fixed overhang on a south-facing window to optimize winter solar heat gain and to minimize the summer cooling load?

Unfortunately there is no simple answer to that question. Many designers just use a two-foot overhang that comes with the normal extension of the top chord of the roof trusses, or that may the limit to fit within allowable zoning setback criteria.

A better way is to size the overhang to the dimensions of the windows being shaded, the heat loss characteristics, and thermal mass of the house. The HOT-2000 computer program will allow you to vary the overhang geometry and determine the optimum dimensions that give you both good space heating and good cooling performance.

Because computer optimization is a long process, here are some rough rules of thumb for sizing fixed overhangs on south windows:

1. Size the overhang projection and height above the window so that full sun will strike the window on December 21 at solar noon. See Fig.1 for an example for Saskatoon's latitude. The projection will be on a line that is 14.5 degrees above the horizontal (starting at the top of the window).
2. Also size the overhang projection and height above the window so that no sunlight directly strikes the window on June 21 at solar noon. Thus, for Saskatoon, the projection will be on a line that is 61.5 degrees above the horizontal, starting at the base of the window. The intersection of the two lines (14.5 degrees and 61.5 degrees) will be where the projection should be located. See Fig. 1. Note that a very long overhang is required with a tall window, as is the case for the 6-foot tall window shown in Fig. 2. Taller windows need longer overhangs than shorter windows.
3. The further north you are, the longer the overhangs must be to shade the windows in the summer period. Conversely, the further south you are, the shorter the overhang required.
4. Recognize that a fixed overhang will never be the optimum solution for controlling solar gain. You may have a very cold day in October where you need full sun, followed by a very warm day when the sun is not needed. A fixed overhang cannot handle both conditions in an optimal manner. Another problem with fixed overhangs is that the sun is at the same location in the sky on March 21 as it is on September 21. In most parts of Canada, the weather on September 21 is very much warmer than it is on March 21.

An exterior blind or a movable awning is an alternative, but both of these require much more maintenance than a fixed roof overhang. Another alternative may be deciduous landscaping. Generally, the Fall colours will still provide shade during those days it is warm, while in the Spring the greenery is still not out when the heat is desired.

5. If you have windows of different heights on the south side of the house, be very careful about trying to match an overhang to each window. Fixed

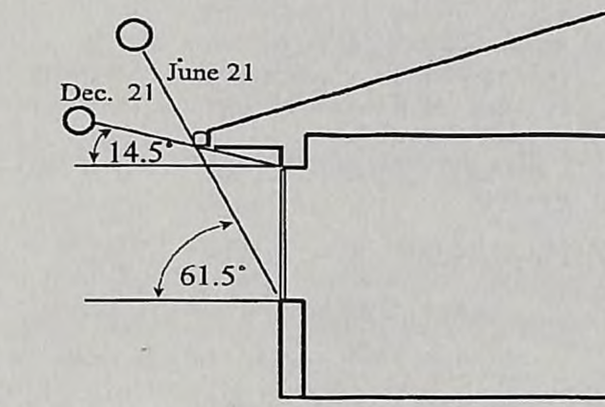


Fig. 1. Sizing an overhang for a south window– Saskatoon Example (52° N)

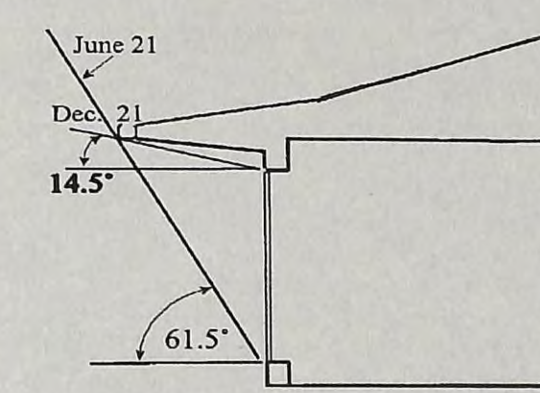


Fig. 2. Sizing a Longer Overhang for a Taller Window— Saskatoon Location (52° N)

overhangs make up a good part of the aesthetics of a house. Varying the overhang sizes for different window heights could result in a very unusual looking dwelling. Size the overhang for the average height of the windows across the facade.

Here are some rules for north, west and east windows:

1. North facing windows generally have the sun shining on them for such a short time at Canadian latitudes that no overhangs are necessary.

2. East and west facing windows are very hard to shade with fixed overhangs, as the sun angles are very low in the mornings and afternoons in the warmer periods of the year. Try to minimize windows on these orientations. Some designers have used fixed vertical exterior shades to control solar gains. Awnings also can work.

As can be seen from the above discussion, a fixed overhang is not the optimum; however, it is a low-tech way to control solar gains that seems to work relatively well. ☼

Building Codes – Why are They Developed?

By John Archer

A quick scan of Canada's National Building Code could lead one to the conclusion that building codes are entirely technical. This would be wrong, however. Building codes articulate social policy. They set out what we, as a society, agree are limitations that should be placed on the private use of property in the context of acceptable levels of risk from hazards in and around buildings.

Until the Industrial Revolution, Europe was primarily rural. Cities were mostly small, with stable populations, and the traditional pace and style of building was satisfactory to meet society's needs. Social convention covered building practice, but written regulations for building construction did appear, usually arising out of catastrophes, such as the Great London Fire of 1666.

The Industrial Revolution changed everything. Cities grew dramatically and became centres of employment. Building became a speculative economic activity, as rising populations needed housing and other facilities. The dramatic growth of cities outstripped traditional approaches to dealing with fire, fresh water and sanitation. The 19th century in Europe saw dramatic social struggles to improve living conditions. Building regulation to address speculative property development, fire and sanitation were a result of that struggle.

The settlement of Europeans in Canada moved, in short order, through the process of using available materials and technology, the adapting of European technology to suit local conditions, the rise of towns and then cities. Prior to Confederation in 1867, what was to become Canada was a mainly a rural society, much like pre-Industrial Revolution Europe. There were small cities – Halifax, Saint John, Quebec City, Montreal, Kingston and Toronto – but the majority of the population lived on farms.

It was a class society, with a ruling economic and social elite in the cities. The ideology of private property was very strong and property rights were very strongly defended in the courts. The ruling elites, having control over the governing processes, had little interest in implementing regulations that might limit the productive use of their property. They also shunned initiatives that would involve the taxing of property, something viewed as paramount to theft.

The sanctity of private property can be seen in the writing of the British North America Act in 1867. The ruling elites in the colonies were not about to give up their hard-won responsible government by handing over power to a central government. As a result, the framers of the BNA Act planned to give the new "Dominion" government as few powers as was feasible, only enough to meet such common needs as defence and trade. As a consequence, the Act gave sole jurisdiction for the regulation of the design and construction of buildings to the provinces. The reference is actually quite vague, stated simply as an exclusive provincial power over property and civil rights.

For the next one hundred years, little was done to regulate building construction. However, the cities in the new confederation began to grow. And with growth came problems. Fire razed every major city before 1900. Waves of typhoid fever, cholera and smallpox ravaged the urban populations nearly every decade.

John Archer is Secretary, Canadian Commission on Building and Fire Codes at the Canadian Codes Centre of the National Research Council's Institute for Research in Construction.

NRC·CNRC

The 1890s were a time of dramatic change. The propertied classes in the cities came to recognize that fire and disease did not distinguish between rich and poor. Private insurance companies began to refuse coverage unless "fire resistant" construction was used. Germ theory was developed and had a dramatic impact on society's perception of housing and urban living conditions. Sanitation engineers began a mission to build water and sewage systems. As the cities grew, so did the size of their politically active and reformist middle classes. By the end of the 19th century, the municipalities in the largest provinces won the power to write and enforce building codes. As the decades passed, and villages grew into small towns, more and more of them took up this regulatory responsibility.

However, a consequence was that by the 1930s, building regulation in Canada was a hodge-podge of inconsistency. There were rural areas with no building construction regulation next to a patchwork of locally created municipal building bylaws. Some bylaws were progressive, but many were based on bad science, a codification of the local carpenters' traditional practice. Some were designed to support local business, many were intended to exclude competition from outsiders. All of them differed in some way.

The situation was chaotic. Architects and engineers complained that they had to learn a different set of rules in each locale. Larger building material manufacturers complained that some municipalities were arbitrarily prohibiting the sale of their building products. Contractors complained that they couldn't use the cheapest or most efficient methods of building. Economists denounced the negative impact of these "barriers to trade" on the Canadian economy at a time when the Great Depression had robbed capitalism of much of its energy and triggered social unrest.

Western Canada had been decimated by drought and the collapse of international wheat markets. Half of Saskatchewan was on what little welfare was available at the time. The unemployed roamed back and forth across the country looking for work. Homelessness became a significant issue and shanty towns began to appear in Canadian cities. Protest movements were gaining strength.

The federal government saw this crisis as a threat to national stability. Action was needed and in response it established the first federal housing program, the Dominion Housing Act of 1935. Its purpose was to both create housing and stimulate construction activity. The government found, however, that the lack of consistent (or often any) rules for the housing construction it was supporting financially resulted in abuses and significant quality failures.

With the encouragement of municipal officials, planners, engineers and architects, in 1937 the federal government asked the National Research Council (NRC) to develop a model building code that it could apply in administering its programs, that could be used by municipalities, and that would also increase the efficiency of the construction economy. In response, NRC brought together leading engineers, architects and building scientists from across Canada to undertake the task.

The objectives of the first National Building Code (1941) are clearly stated in its foreword. It is a document setting out regulations in the distinct areas of construction requirements, fire protection, and health and sanitation. The construction requirements, in addition to setting out "safe" minimums for structural capacity, were intended to address existing deterrents to technical progress and barriers to construction productivity. The fire protection requirements were intended not only to protect a building and its occupants from the effects of fire but to prevent the spread of fire to adjacent buildings. This part of the code introduced the concept of "occupancy" and reflected the hazards associated with each occupancy type in the level of fire protection required. The health and sanitation requirements were intended to achieve minimum conditions of light and ventilation in rooms in buildings and access to a safe supply of potable water in buildings and water closets.

For its time, the 1941 National Building Code was a very progressive document, both technically and socially. Continually updated in subsequent editions by a dedicated group of volunteers, the NBC has been an important foundation for the quality of life of Canadians ever since. The evolution to an objective-based format signals a new era. ☼

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